1. ACAS PERFORMANCE DURING HVR ENCOUNTERS

1.1 As of 2006, data collected by ACAS monitoring programs continue to show that a large percentage of ACAS RAs are a result of climbing or descending aircraft maintaining a high vertical speed while approaching their ATC-assigned altitude. Changes have been made to the ACAS SARPs and guidance material (see Annex 10) that have been effective in reducing the frequency of occurrence for these types of RAs, but these types of RAs continue to occur with a high degree of regularity in airspace throughout the world. It has been determined that no further changes are feasible within ACAS to address this issue without resulting in an unacceptable degradation of the safety provided by ACAS.

1.2 Modern aircraft and their flight guidance systems (autopilots, flight management systems, and autothrottles) are designed to fly specific flight profiles that provide fuel and time efficient flight paths. An integral concept of the design of the flight guidance systems includes allowing an aircraft to quickly climb to higher, more efficient operating altitudes and to remain at these altitudes as long as possible, which results in descents also being made with high vertical speeds. For economic benefits, the high vertical speeds used in a climb or descent are retained as long as feasible before initiating a smooth capture of the aircraft's assigned altitude.

1.3 The design of the flight guidance systems can result in vertical speeds in excess of 15 m/s (or 3 000 ft/min) until they are within 150 m (or 500 ft) of the aircraft's assigned altitude. When a climbing or descending aircraft maintains a vertical speed in excess of 15 m/s (or 3 000 ft/min) until it is within 150 m (or 500 ft) of the aircraft's assigned altitude, it is less than 30 seconds away from being at the adjacent IFR altitude, which may be occupied by an ACAS-equipped aircraft flying level at that altitude. If the intruder aircraft is horizontally within the protected area provided by ACAS, there is a high probability that an RA against the climbing or descending aircraft will be issued just as the intruder aircraft begins to reduce its vertical speed to capture its assigned altitude.

1.4 Figure 1 provides a representation of the encounter geometry of this scenario. ACAS typically issues a Climb RA, which calls for a climb at 8 m/s (or 1 500 ft/min). Depending on the altitude of the level aircraft, this RA will typically be issued when the intruder aircraft is approximately 150 m (or 500 ft) below its assigned altitude and the vertical speed of the intruder is in excess of 15 m/s (or 3 000 ft/min).

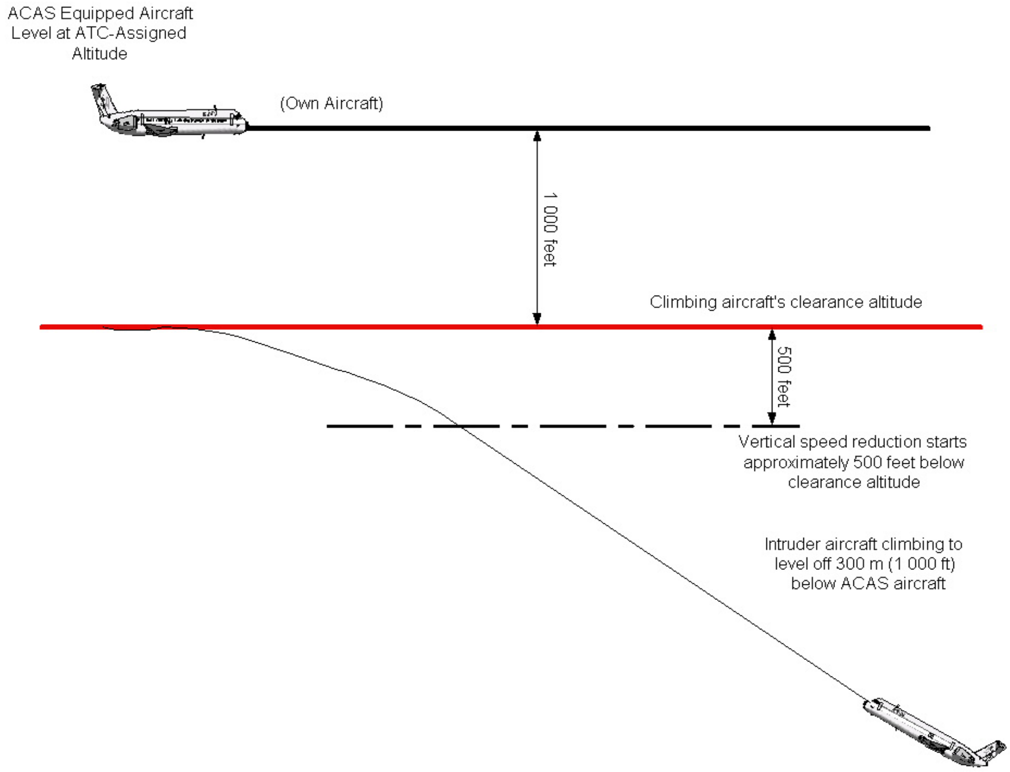

Figure III-3-3-1. Representative HVR Encounter Geometry

1.5 ACAS in the level aircraft is tracking a climbing/descending (intruder) aircraft and is using replies to its interrogations to determine the intruder's altitude and its vertical speed. The ACAS track is updated once per second. The intruding aircraft's track information, along with the track of the level ACAS aircraft (own aircraft), is used within ACAS to determine if the intruder aircraft is currently a threat or will be in the near future.

1.6 In determining whether the intruder aircraft will be a threat in the future, ACAS projects the existing vertical speed of the intruder and own aircraft, to estimate the vertical separation that will exist at the closest point of horizontal approach during the encounter. These projections use the current vertical speed of both aircraft, and ACAS is not aware of the intruder aircraft's intent to level at an adjacent altitude above or below its own aircraft's current altitude. Should this projection be less than the ACAS desired vertical separation, an RA will be issued.

1.7 Should the intruder aircraft continue to climb/descend with the high vertical speed until it is 15 to 25 seconds from being at the same altitude as the level ACAS aircraft (again depending on the ACAS aircraft's altitude), ACAS will issue an RA calling for the own aircraft to manoeuvre to increase vertical separation from the intruder aircraft.

2. OPERATIONAL IMPACTS OF RAS RESULTING FROM HVR ENCOUNTERS

2.1 Shortly after ACAS issues the RA (Climb RA for the encounter geometry shown in Figure III-3-3-1), the intruder aircraft begins reducing its vertical rate to capture its assigned altitude.

2.2 While the intruder aircraft is initiating its level off, the ACAS aircraft has started responding to its RA and may have left its assigned altitude. Both pilots and controllers agree that RAs issued in this encounter geometry are unwelcome. The RAs can be disruptive to a controller's current traffic flow and plans, and thus represent an increase in their workload. The response to the RA can also result in a loss of standard ATC separation if another aircraft is above the ACAS aircraft.

2.3 Pilots have reported that these types of RAs decrease their confidence in the performance of ACAS. These RAs typically occur repeatedly in the same geographic area and repeated RAs of this type result in pilots being reluctant to follow the RA. This can be potentially hazardous in the event that the intruder aircraft passes through its assigned altitude.

3. FREQUENCY OF OCCURRENCE

3.1 ACAS monitoring shows that the frequency of occurrence is dependent on how airspace is structured and managed. Data collected during 2001 indicate that up to 70% of the RAs issued are caused by the intruder aircraft maintaining a high vertical speed while approaching its assigned altitude. Depending on the airspace structure and the flow of traffic, it is possible to have several of these RAs issued within one hour, although airspace containing a lower density of traffic will have relatively few RAs of this type. Some air traffic service providers have been able to change their traffic flows and/or operational procedures to reduce the occurrence of these types of RAs, but these types of RAs continue to occur with a high degree of regularity in airspace throughout the world.

3.2 HVR RAs have been observed in both terminal and en route airspace, although because of the previously higher vertical separation above FL 290 in non-RVSM airspace, very few RAs of this type have been observed above FL 290 in the past. With the current reduced separation, it is possible that HVR RAs may occur more frequently above FL 290 in RVSM airspace. Many HVR RAs occur in close proximity to large airports where departures are kept below arriving aircraft until some distance from the airport before being allowed to climb to higher altitudes and a large percentage of these RAs occur in geographic areas where there is a concentration of climbing and descending aircraft.

4. ACAS FEATURES THAT REDUCE THE LIKELIHOOD OF RAS BEING ISSUED IN THESE SITUATIONS

4.1 ACAS recognizes HVR encounters, such as that shown in Figure III-3-3-1. When this encounter geometry is detected, the issuance of RAs can be delayed by up to ten seconds. This delay allows additional time for the intruder aircraft to initiate a level off and for ACAS to then detect this level off. However, when the intruder aircraft maintains a vertical speed in excess of 15 m/s (or 3 000 ft/min) until it is within 150 m (or 500 ft) of its assigned altitude, even this 10 second delay may be insufficient for ACAS to detect the level off, and an RA may be issued. Safety studies have shown that further delays in issuing the RA result in unacceptable degradation in the safety provided by ACAS.

4.2 Consideration has also been given to providing ACAS with information regarding the intruder aircraft's intent. This is not considered to be a viable approach to reducing these types of RAs while retaining the existing level of safety provided by ACAS. Currently, it has not been possible to identify any additional changes to ACAS that will provide a further reduction in the frequency of these potentially disruptive RAs.

5. OPERATOR-SPECIFIED PROCEDURES

5.1 Because of the operational impacts to pilots and controllers caused by these types of RAs, the continued existence of these RAs, and the constraints on further modifications to ACAS, operators should specify procedures by which an aeroplane climbing or descending to an assigned altitude or flight level with an autopilot engaged may do so at a rate less than 8 m/s (or 1 500 ft/min) within 300 m (or 1 000 ft) of the assigned level. Such procedural changes should provide an immediate operational benefit to both pilots and controllers by reducing the occurrence of HVR RAs.

5.2 The implementation of such procedures will not completely eliminate these RAs, but in the absence of other solutions such as the redesign of airspace, their implementation will reduce the frequency of these undesirable RAs until a technical solution can be developed. Options that operators should consider include flying the entire climb or descent at a pre-selected rate, modifying the climb or descent in the latter stage, and employing use of less than economic climb thrust in lower airspace.

5.3 A recommended procedure would call for a climbing or descending aircraft to adjust its vertical rate when approaching an assigned altitude or flight level, *and* when the pilot is aware that there is an aircraft at or approaching an adjacent altitude or flight level. The crew can be made aware of the presence of that aircraft by several means, including information provided by an air traffic controller, an ACAS TA, or by visual acquisition. When a crew of an intruder aircraft becomes aware that another aircraft is at or approaching an adjacent altitude or flight level, it is recommended that the vertical speed of the intruder aircraft be reduced to less than 8 m/s (or 1 500 ft/min) when approaching an altitude that is 300 m (or 1 000 ft) above or below the assigned altitude or flight level.

Note.— There is no intent in this recommendation to require a manual modification in vertical speed for every level off. This is not necessary and would introduce a significant increase in pilot workload.

5.4 When the autopilot is in the altitude capture mode, subsequent vertical mode changes such as the selection of a vertical speed mode may cause some autopilots either to cancel the altitude capture or to not properly capture the selected altitude. Altitude deviations represent a significant percentage of pilot deviations and the performance of the autopilot during any altitude capture should be closely monitored in accordance with existing procedures.

5.5 Additional tasks may be required during some level off manoeuvres. However, the procedure is a recommendation, not a requirement. Further, the procedure does not suggest that adjustments to the aircraft's vertical speed be made unless the pilot is aware that traffic is at an adjacent altitude.

5.6 The operator should specify procedures that the pilot may use to reduce vertical speed when an autopilot is engaged, as appropriate for the type of aircraft. Also, the operator should consider authorizing pilots to use a modest vertical speed throughout a climb or descent when the vertical interval is not large – such as a change of altitude in a holding pattern - specifying how this should be accomplished.

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